REMARKS

Claims 29-43 are pending in the application. By this amendment, claims 29, 30, and 42 are amended, and claim 43 is newly presented. Applicant requests reconsideration and allowance in view of the above amendments and the following remarks.

Interview

Initially, Applicant would like to thank Examiners Shah and Day for the courtesy of the January 20, 2010 personal interview. The Examiner-prepared Interview Summary appears to be accurate.

Objections/Rejections

All issues raised in the Office Action relate to alleged new matter, scope of enablement, written description, or indefiniteness issues. In other words, there are no art-based rejections. Applicant will address the "quick" issues first.

Written Description

Claims 29-42 are rejected under 35 U.S.C. § 112, first paragraph (section 7-2 of the Office Action) based on recitation of the maximum temperature being calculated using different functions depending on the value of the heating parameter. According to the Office Action, the specification discloses calculating a maximum temperature increase ΔT (i.e., not the maximum temperature, *per se*) using different functions depending on the value of the heating parameter, and therefore the specification does not support the recited limitation. Applicant traverses the rejection.

As explained in the specification for the disclosed embodiment, the maximum temperature T for a given cycle of heat-generating loading is determined by adding the maximum temperature increase ΔT to the temperature of the rotary member before the loading begins. See, for example, application paragraphs **[0033]** ("According to a method of the invention, a maximum temperature on the surface of the brake disk 2 is calculated by summing a basic temperature before a brake application with a temperature increase during the brake application.") and **[0080]** ("By summing the value worked out for the basic temperature with the

calculated temperature increase for subsequent brake application, a value is obtained for a maximum total temperature.") along with application Figure 4. Thus, if maximum temperature T is calculated in the disclosed embodiment using the maximum temperature increase ΔT (i.e., by adding it to the pre-loading temperature), and if the maximum temperature increase ΔT is calculated using different functions depending on the value of the heating parameter, then it follows that the maximum temperature T is calculated using different functions (which "feed into" the value of ΔT) depending on the value of the heating parameter. Accordingly, Applicant traverses the rejection and requests that it be withdrawn.

Scope of Enablement

Claims 29 and 31-42 are rejected under 35 U.S.C. § 112, first paragraph (section 8-1 of the Office Action) for reciting a heating parameter that is based on heat-related attributes or characteristics of the rotary member and the length of time for which the rotary member is subject to a given cycle of heat-generating loading, which is deemed to be impermissibly broader than what is enabled by the disclosure. Per agreement at the interview, Applicant has specified in independent claims 29 and 42 that the parameter is based on the thermal diffusivity constant α of the rotary member and the length of time for which the rotary member is subject to a given cycle of heat-generating loading, with the definition of α being provided in the specification as well as in the claims. (To avoid redundancy, Applicant removed the definition of α from claim 30, which depends from claim 29 and specifies that the heating parameter is Fo, and left it out of new claim 43, which depends from claim 42.) Accordingly, Applicant requests that the scope-of-enablement rejection be withdrawn.

Indefiniteness

Claims 29-42 are rejected under 35 U.S.C. § 112, second paragraph (section 10-1 of the Office Action) for alleged indefiniteness. In particular, the Examiner astutely notes that while the independent claims specify that the maximum temperature is calculated using one function if the heating parameter is less than a predefined limit value of the heating parameter; using another function if the heating parameter is greater than the predefined limit value; and using either function if the heating parameter is equal to the predefined limit value, the claims need to

specify that the functions intersect at the predefined limit value, such that the same result is obtained using either function, in order to avoid ambiguity. Applicant has amended the claims accordingly and requests that the rejection be withdrawn.

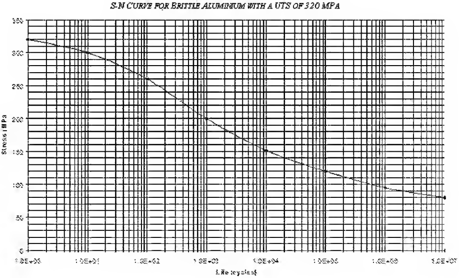
New Matter

The specification amendments filed September 10, 2009 are objected to for allegedly introducing new matter (section 5 of the Office Action), and claims 29-42 are rejected under 35 U.S.C. § 112, first paragraph (section 7-1 of the Office Action) for allegedly not being supported by the application as originally filed. In particular, it is the amendments to paragraphs **[0092]**, **[0093]**, and **[0094]** that allegedly introduce new matter. Applicant disagrees with the objection and traverses the rejection.

As explained at the interview and as indicated in the specification, the present invention utilizes concepts that are analogous to those used to assess fatigue damage to a part that is subjected to cyclical loading. See, for example, paragraphs **[0027]** ("Each brake application produces a temperature cycle of the brake disk. As described further below, the life of the brake is described by the number of surface-temperature cycles in the form of a power function (Figure 5) in an analogous manner to the S/N curve obtained in the case of fatigue.") and **[0092]** ("With the aid of a linear part damage theory (Palmgren-Miner), two accumulated damage values are evaluated") as well as application Figure 5. Therefore, Applicant will re-review below the conceptual underpinnings of fatigue analysis – Applicant's representative explained them once before at the interview[2] – so that the carryover applicability of the concepts, and hence the non-new-matter nature of the specificatoin amendments, can be seen.

[2] As noted during the interview, Applicant's undersigned representative studied fatigue analysis during his undergraduate education in aerospace engineering, and he performed fatigue analyses on the F/A-18 fighter aircraft for a year while working at McDonnell Douglas before attending law school. Therefore, Applicant's undersigned representative considers himself to be well qualified to provide this fundamental review without resort to independent Declarations to support it. Furthermore, a similar review that is slightly more in-depth can be found at http://en.wikipedia.org/wiki/Metal_fatigue .

In general, cyclic loading and unloading will eventually cause a part to fail due to fatigue at a stress level[3] that is lower than the stress level the part could otherwise carry statically without failure (e.g., without plastic deformation or rupture). This is due to migration and accumulation of crystalline defects, flaws, impurities, microcracks at the intergranular boundaries, etc., in a metal part as the part is cyclically loaded and unloaded, and the fatigue life of the part (i.e., the number of cycles the part can withstand before failure), which is typically designated as N, generally varies inversely and logarithmically with the magnitude of the loading. Thus, for example, if a part (e.g., a bar with a cross-sectional area of one square inch) can carry a load of 100,000 pounds (causing a stress level of 100,000 PSI) statically before failure, it may fail after, say, 1000 cycles of consistent cyclical loading to 80,000 pounds; 10,000 cycles of consistent cyclical loading to 60,000 pounds; 100,000 cycles of consistent cyclical loading to 40,000 pounds; 1.5 million cycles of consistent cyclical loading to 20,000 pounds; etc. The number of cycles to failure also depends on the particular material being used. This relationship between the level of stress to which a part is subjected cyclically and the number of cycles to failure can be illustrated in an empirically derived, material-specific S/N curve, one example of which is illustrated below (copied from Wikipedia entry).



[3] Stress is expressed in terms of PSI (pounds per square inch) or Pa (Pascals), i.e., the load being carried by a part divided by the cross-sectional area of the portion of the part over which the load is being carried.

Each point along the S/N curve (i.e., fatigue life N for a given cyclical loading magnitude) assumes that all loading cycles over the lifetime of the part are to the exact same stress level. In real life, however, that does not happen. However, according to the linear partial damage theory proposed by Palmgren and popularized by Miner, every cycle of loading to which a part is subjected causes an incremental amount of damage equal to 1/N, with N being the fatigue life associated with the particular stress level to which the part is subjected, and the total amount of damage accumulated to any given point in time is equal to the sum of every incremental amount of damage which has been done to the part. Thus, for example and using the numbers given above, if a part has been subjected to five cycles of loading to 80,000 pounds, 250 cycles of loading to 60,000 pounds, 35,000 cycles of loading to 40,000 pounds, and 100,000 cycles of loading to 20,000 pounds, then the part will have accumulated a total amount of damage equal to 5/1000 + 250/10,000 + 35,000/100,000 + 100,000/1,500,000, or 0.45.

Furthermore, according to the Palmgren-Miner theory, the total accumulated damage a part can sustain before it fails is a constant value, which may range from 0.7 to 2.2 (determined experimentally) depending on the particular material being loaded. However, for design purposes (e.g., predicting the life of a part given an anticipated "spectrum" of loading over the life of the part), the value at which failure will occur is often taken to be 1.0. Additionally, for calculation efficiency, it is common practice to divide the overall range of cyclical loads a part is expected to encounter into various sub-ranges and to use a fatigue life N_x, e.g., a mean or median value for the particular sub-range, that is representative of the given sub-range, then tally the number of loading cycles n_x that have been encountered and that fall within each of the given loading sub-ranges. Thus, in practice, a part will be predicted to fail when the accumulated damage $\sum_{x=1}^{j} \frac{n_x}{N_x} = C$, with j being the number of sub-ranges in the analysis and C typically taken to be 1.

Turning now to the present application, as noted above and during the interview, the present invention utilizes concepts that are analogous to those used to assess fatigue damage (explained above), but which concepts are based on damage that has been done to a rotary part by heat-inducing loading. From the above discussion, it should be clear that a fundamental concept used in fatigue analysis is the S/N curve. Analogizing specifically to that concept (see

paragraph [0027]), the present application discloses in Figure 5, reproduced below, a similar relationship between the maximum surface temperature to which a rotary member is heated cyclically and the corresponding life of the rotary member, as expressed in terms of number of cycles.

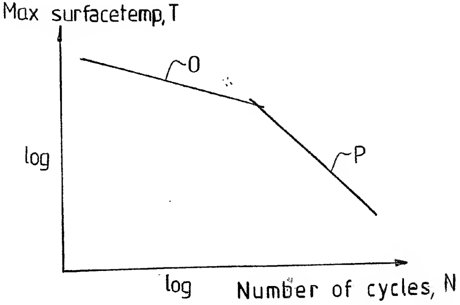


FIG 5

Furthermore, the application specifically refers to the partial damage theory or the Palmgren-Miner theory for assessing consumed life ("damage durability") or accumulated damage values. See paragraphs [0028] ("With the aid of a part damage theory, the damage durability consumed by the braking cycles in relation to damage durability obtained from tests is then calculated") and [0092] ("With the aid of a linear part damage theory (Palmgren-Miner), two accumulated damage values are evaluated"). Further still, the application specifically refers to performing the analysis for each of severalo different temperature ranges. See paragraphs [0017] ("the total temperature value produced, or a converted damage value, for each loading instance is stored in a position in a memory, which position defines a specific temperature range or damage range. In this way, opportunities are afforded for using the part damage theory. More precisely, the damage or consumed life is calculated on the basis of the number of times each

specific range has been reached and knowledge of the damage durability of the rotary member") and **[0081]** ("the number of times the surface temperature of the brake disk reaches each of a large number of specific, predetermined temperature ranges is stored (or logged). . . . Generally, it can be that the number of braking cycles is stored in classes that correspond to different energy, damage and/or temperature ranges").

Thus, given that repeated reference to concepts borrowed from fatigues analysis, i.e., S/N curves and partial damage, it is clear that the conceptual underpinning behind the present invention is that a part will fail due to heating-induced damage (i.e., its life will have been consumed) when the total damage caused by all previously encountered cycles of heat-inducing loading reaches some predefined value (in this exemplary case 1.0; see paragraph **[0100]**), which is directly analogous to application of Miner's Rule (or the Palmgren-Miner Rule) in fatigue analysis. Furthermore, it is equally clear that the accumulated amount of damage is assessed precisely as recited in steps d) and e) of the two independent claims:

> d) [ ] the number of heat-generating loading cycles [i.e., n_x] which have occurred in each of a plurality of pre-defined temperature categories [is tabulated], wherein each of said pre-defined temperature categories corresponds to a range of maximum temperatures that may be generated in association with the rotary member in any given cycle of heat-generating loading; and
>
> e) using the [ ] number of heat-generating loading cycles [n_x] which have occurred in each of said plurality of pre-defined temperature categories [as tabulated in step d)] and using pre-established, heating-related life expectancy information for said rotary member [i.e., N_x, the curve for which is depicted in application Figure 5], [ ] a cumulative amount of heating-induced damage which has occurred to said rotary member [is assessed] using a partial damage theory[.]

Furthermore, turning to the amendment that allegedly introduced new matter into the specification, as filed, application paragraphs **[0092]**, **[0093]**, and **[0094]** indicated that "accumulated damage values" can be evaluated as "D1=S(Tm1*n1) (applies for the [portion of the] curve P [shown in Figure 5])" and "D2=S(Tm2*n2) (applies for the [portion of the] curve O [shown in Figure 5])." As the Examiner astutely noted previously, however, the term S was used in those two equations without being defined, but it had also been used earlier in the application, in connection with defining Fo, to refer to the thickness of the rotary member. Therefore,

according to the Examiner, the claims were not enabled by the application as originally filed. See pages 4-5 of the December 19, 2006, Office Action and page 4 of the November 25, 2008, Final Office Action.

Applicant notes, however, that every other parameter or variable referenced in the application is, in fact, defined. Furthermore, if S were taken to be a thickness, then dimensional analysis (i.e., consideration of just the units associated with the various parameters) would show that something was amiss with the equations for D1 and D2. After all, a length (thickness) times a temperature times a unitless number (m1 or m2, which are the exponents in the equations at paragraphs **[0086]** and **[0087]**) times another unitless number (n1 or n2, which are the number of heating cycles that have been experienced) does not yield a unitless number, which is how an accumulated amount of damage should be expressed. Therefore, given the lack of a definition for S (particularly in light of there being definitions for all other parameters in the application), coupled with the improper result of a dimensional analysis, Applicant submits that one of skill in the art would have easily recognized that there were errors in the equations as originally filed.

Recognizing the existence of such error, one of skill in the art would, Applicant submits, have resorted to fundamental principles to figure out the appropriate expressions for himself or herself. In this case, paragraph **[0092]** specifically indicates that the accumulated damage values expressed in paragraphs **[0093]** and **[0094]** are developed "[w]ith the aid of a linear part damage theory (Palmgren-Miner)[.]" Thus, from the discussion above, we know that D1 and D2 – the accumulated damage amounts – can each be expressed in the form $D = \sum n/N$ (subscripts omitted), where the summation is taken over all of the temperature sub-ranges used in the analysis (i.e., $x = 1$ to j). Furthermore, as originally filed, the equations at paragraphs **[0093]** and **[0094]** were expressed in terms of T and m1 (paragraph **[0093]**) or m2 (paragraph **[0094]**), but not in terms of N. Given the appearance of T and m1 or m2 in those two equations and the "disappearance" of N from those two equations, it should be apparent that some sort of substitution was done.

Notably in this regard, paragraph **[0084]** indicates that the life of the rotary member is calculated empirically, i.e., "by means of real tests [that are] carried out," then paragraph **[0085]** indicates that the strength (i.e., the life) of the rotary can be described by the two equations at

paragraphs **[0086]** and **[0087]**.[4] Further still, those two equations for the strength (life) of the rotary member are expressed in terms of T, N, and m1 or m2, *viz.*, $T^{m1} * N = C1$ (paragraph **[0086]**) or $T^{m2} * N = C2$ (paragraph **[0087]**). Moreover, paragraph **[0092]** indicates that, with the aid of a linear part damage theory, the accumulated damage values are evaluated "from the measurements[.]" Given the proximity of that statement to the equations at paragraphs **[0086]** and **[0087]**, which two equations are based on measured data (i.e., "real tests," as per paragraph **[0084]**), then it should be apparent that the equations at paragraphs **[0086]** and **[0087]** were rearranged to express N in terms of T and m1 or m2, and those rearranged expressions were then substituted into the fundamental expression for accumulated damage. That substitution leads us to the amendments Applicant submitted previously, which simply made explicit that which had been done implicitly and, in so doing, corrected a clear error. Thus, as amended, the application should, in fact, indicate as follows:

[0086] $T^{m1} * N = C1\underline{;\ therefore,\ N = C1/T^{m1} = C1 * T^{--m1}}$ (applies for curve P)

[0087] $T^{m2} * N = C2\underline{;\ therefore,\ N = C2/T^{m2} = C2 * T^{--m2}}$ (applies for curve O)

[0092] ~~With the aid of~~ Under a linear part damage theory (Palmgren-Miner), total accumulated damage D to any given point in time may be expressed as the sum, over all encountered loading ranges, of partial damage n/N accumulated within each loading range, i.e., D = ∑ n/N. Therefore, substituting the expressions above for N into that expression, two accumulated damage values D1 and D2 can be expressed as ~~are evaluated from the measurements~~

[0093] $D1 = \underline{\sum n_1/(C1 * T^{--m1}) = \sum n_1 C1^{-1} * T^{m1} = C1^{-1} * \sum n_1 * T^{m1}}$ ~~S(Tm1 * n1)~~ (applies for the curve P)

[0094] $D2 = \underline{\sum n_2/(C2 * T^{--m2}) = \sum n_2 C2^{-1} * T^{m2} = C2^{-1} * \sum n_2 * T^{m2}}$ ~~S(Tm2 * n2)~~ (applies for the curve O)

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[4] The equations at paragraphs **[0086]** and **[0087]** refer to portions P and O, respectively, of the curve shown in Figure 5, and that curve relates the life (in terms of cycles) of the rotary member to the maximum surface temperature. Therefore, it is clear that the term "strength" in paragraph **[0085]** is referring to the cyclic life of the rotary member and not to its physical strength.

In short, Applicant submits that the substitutions that were done to derive the equations in paragraphs **[0093]** and **[0094]** as should have been (and now are) expressed were no more complex or opaque than, for example, substituting the expression $i = V/R$ (derived from the formula $V = i * R$ relating voltage, current, and resistance) into the equation $P = i * V$ (relating electrical power, current, and voltage) to obtain the equation $P = V^2/R$. Therefore, Applicant submits, the amendments did not introduce any new matter into the specification; the objection is without basis; and the rejection should be withdrawn.[5]

In view of the foregoing, Applicant submits that all pending claims are in condition for allowance, and timely Notice to that effect is respectfully requested.

The undersigned representative authorizes the Commissioner to charge any additional fees under 37 C.F.R. 1.16 or 1.17 that may be required, or credit any overpayment, to Deposit Account No. 14-1437, referencing Attorney Docket No.: 7589.0150. PCUS00.

In order to facilitate the resolution of any issues or questions presented by this paper, the Examiner may directly contact the undersigned by phone to further the discussion.

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[5] As pointed out during the interview, the specific expressions for D1 and D2 are not even required in order to be able to practice the claim-recited methodology. That should be clear from the portion of the discussion above extending through the recitation of claim steps d) and e) at page 13, i.e., the portion of the discussion that precedes any discussion of the amended specification paragraphs. Therefore, the enablement rejection should be withdrawn for that reason, too.